

## Cubic phase distortion of single attosecond pulses being reflected on narrowband Mo/Si filtering mirrors

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**Abstract:** We show that cubic phase distortion caused by narrowband Mo/Si multilayer filtering X-ray mirrors may considerably increase the time duration of single attosecond pulses.

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### Introduction

After reaching the sub-5 fs regime in the field of high power ultrashort laser pulse generation [1], an extended effort has been made in order to push the temporal resolution limit in the sub-femtosecond or attosecond (as) regime. Performing experiments on this timescale is extremely exciting: a many of fundamental physical processes, such as ultrafast electron dynamics, evolve in the sub-femtosecond regime. The possibility of generating attosecond pulses was predicted by Farkas and Tóth [2], and Antoine et al [3] by exploitation of high harmonic generation (HHG). High harmonics are typically generated in rare gases following the ionization process induced by high intensity lasers pulses and exhibit discrete frequencies that are the odd multiples of the original laser frequency. According to theory, selecting a proper range of these harmonics one can generate a train of attosecond pulses.

Single attosecond pulses can be obtained using a few cycle – about 5 fs – laser pulses for generation of a continuum in the soft x-ray spectrum, which continuum must be properly filtered by narrowband Si/Mo multilayer mirrors [4]. In order to obtain transform limited attosecond pulses, the intrinsic chirp of the continuum [5] should be compensated as well: chirped mirror structures developed for X-ray wavelengths [6] may solve this problem. An alternative approach has been recently proposed by Kim et al. [7] who used a thin Sn (Tin) layer for spectral filtering and compensation of the positive linear chirp of the continuum. This latter approach is limited by the fact that spectral filtering and dispersion compensation can not be independently adjusted.

In this paper we investigate phase properties of Mo/Si multilayer filtering mirrors developed for single attosecond pulse generation experiments. We show that cubic phase distortion originating from narrow bandwidth ( $\Delta E \approx 3$  eV) Mo/Si multilayer filtering mirrors results in longer time duration and multiple pulsing. Interestingly, this effect reduces for higher bandwidth filtering mirrors, i.e., for shorter attosecond pulses.